Multimode filter

Reference to Related Application

The present application claims priority from Taiwan Application No.090108828, entitled "Multimode filter," filed on April 12, 2001.

Background of the Invention

Field of the Invention

This invention relates generally to a multimode filter, and more particularly to a multimode filter in an optical storage device.

Description of the Related Art

Optical storage devices are widely utilized in many fields. CD-ROMs have become basic devices on personal computers (PCs). With the popularity of CD-Rs and CD-RWs, it is more convenient for users to record data or music. Conventionally, the recording mode of optical disk is constant linear velocity (CLV). As a result, recordable optical devices, for example CD-R, CD-RW, DVD-R, DVD-RW, DVD+RW or DVD-RAM, are recorded with CLV mode. It does not matter whether the position of the pick-up head of the optical device is at the outer or inner side of the optical disk, the speed of recording data into the disk is always kept constant. When the optical storage device operates with high rotational speed, the speed of data recording into the disk is limited by the rotational speed of the spindle motor. Such bottleneck can be resolved by using constant angular velocity (CAV) recording mode. For example, the rotational speed of the inner side of the disk is 8000 rpm when the optical storage device records data with16x CLV mode. If the recording speed of the optical storage device is changed to 16x CAV mode at the inner side of the disk, the rotational speed at the outer side of the disk becomes 40x.

To label the location of the data in the disk, the tracks of the disk are divided into many sectors units. These sector units include minutes, seconds and blocks. A latest development in labeling is to form the edges of the tracks with a shape like a wave profile. As a result, when the disk is rotated, the reflected laser beam by the edges of the tracks with a shape like a wave profile forms a wobble signal. By using the frequency modulation (FM) the absolute time in pre-groove

(ATIP) is encoded in the wobble signal. Thus, when the optical storage device receives the reflected signals from the reflected laser beam, it extracts the wobble signal from the reflected signals and decodes the wobble signal to attain the ATIP, thereby the position of the pick-up head is known.

FIG. 1A is the profile of a recordable disk. Disk 100 is a recordable disk, for example CD-R, CD-RW, DVD-R, DVD-RW, DVD+RW or DVD-RAM. The disk 100 is grooved with tracks 130 for data storage. FIG. 1B shows the detailed structure of tracks 130. As shown in FIG. 1B, the edges 135 of the tracks 130 are formed with a shape like a continuous wave profile. The position of the pick-up head is known by extracting the wobble signal and decoding the ATIP. Thus, extracting the wobble signal is critical for identifying the position of the pick-up head. FIG. 1C shows the relationship of a photo-detector (PD) and the tracks 130. The PD includes a sensor 171, a sensor 173, a sensor 175, and a sensor 177. The spot area 150 of the laser is shown by dotted line. The sensors 171, 173, 175, 177 can sense the laser simultaneously. When the optical storage device is using a CLV mode for recording, the frequency of the wobble signal is 22.05KHz ±1KHz, where the center frequency is fixed to 22.05 KHz. Since the ATIP is encoded in the wobble signal, the ATIP can be known by extracting the wobble signal. A common way to extract the wobble signal is using the main beam push pull signal, i.e. the tracking error signal. If the values sensed by the sensors 171, 173, 175, 177 are A, B, C, and D respectively, then the main beam push pull signal is (A+D)- (B+C). By filtering the main beam push pull signal with a CLV mode filter of center frequency of 22.05 KHz, a narrow bandwidth wobble signal can be extracted.

Turning now to FIG.2, it shows a device for extracting a wobble signal when the optical storage device is using CLV mode. By using a CLV mode filer 270 to filter a main beam push pull signal 250, the wobble signal 255 is extracted. Since the center frequency of the CLV mode filter 270 is 22.05 KHz when the speed of the optical storage device is 1x, the frequency of the narrow bandwidth wobble signal 255 extracted from the CLV mode filter 270 is also 22.05 KHz.

When the speed of the optical storage device with CLV mode is 1x, since the frequency of the wobble signal is fixed to 22. 05KHz ±1KHz, the wobble signal can be extracted by a filter with a fixed center frequency. However, when the

optical storage device is using CAV mode, the frequency of the wobble signal increases with the linear velocity. The frequency of the wobble signal increases from 22.05KHz to 22.05×2.505KHz. In other words, the filter with fixed center frequency is not suitable for CAV mode. Since the frequency of the wobble signal is changed with the radial position of the pick-up head for CAV mode, a method is proposed for adjusting the center frequency of the filter dynamically to extract the wobble signal. However, the method can only be realized when the frequency of the wobble signal is known. The moving speed of the pick-up head is quite high when it is searching data; it is difficult to know the exact frequency of the wobble signal at the moment. Thus, the idea of dynamically adjusting the center frequency of a filter is not realized yet and becomes a bottleneck of developing CAV technology.

Summary of the Invention

It is therefore an object of the present invention to provide a multimode filter to enhance the access speed of an optical storage device with CLV or CAV mode.

According to the object of the invention, a preferred embodiment is described as follows:

A multimode filter comprises a CLV mode filter, a CAV mode filter, and a switch. The center frequency of the CLV mode filter is fixed, and the CLV mode filter is used to extract a wobble signal for an optical storage device with CLV mode. The CAV mode filter comprises a high pass filter and a low pass filter. The CAV mode filter has a wide range of the operational frequency bandwidth and is used to extract a wobble signal for an optical storage device with CAV mode. By using the CLV mode filter, an error signal is filtered and a narrow bandwidth wobble signal is extracted. By using the CAV mode filter, an error signal is filtered and a wide bandwidth wobble signal is extracted. The switch is permitted to select either the CLV mode filter or the CAV mode filter according to the recording mode of the optical storage device.

Other objects and advantages of the present invention will become apparent from the following descriptions, taken in connection with the accompanying drawings, wherein, by way of illustration and example, an embodiment of the

present invention is disclosed.

Brief Description of Drawings

The following detailed description, given by way of examples and not intended to limit the invention to the embodiments described herein, will be best understood in conjunction with the accompanying drawings, in which:

FIG. 1A is a diagram showing the profile of a recordable disk;

FIG. 1B is a diagram showing the detail structure of tracks;

FIG. 1C is a diagram showing the relationship of a photo-detector and the tracks 130;

FIG. 2 is a diagram showing device for extracting a wobble signal when the optical storage device is using CLV mode;

FIG. 3 is a block diagram of a multimode filter according to a preferred embodiment of the invention.

FIG. 4 is a block diagram of the CAV mode filter in FIG. 3.

FIG. 5 is a diagram showing the distribution of servo error signals, radio frequency signals, and bandwidth of a CAV mode filter.

Detailed Description of the Invention

Detailed descriptions of the preferred embodiment are provided herein. It is to be understood, however, that the present invention may be embodied in various forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the present invention in virtually any appropriately detailed system, structure or manner.

The idea of the present invention is using a CAV mode filter with wide bandwidth to extract a wobble signal. The bandwidth of the CAV mode filter can cover the frequency range of the wobble signal. Thus, no matter the pick-up head is located at the inner or outer side of a disk, the frequency range of the wobble

signal is within the bandwidth of the CAV filter, so that the wobble signal can be extracted efficiently.

Turning now to FIG. 3, it shows a block diagram of a multimode filter according to a preferred embodiment of the invention. The multimode filter 300 comprises a CLV mode filter 270, a CAV mode filter 370, and a switch 390. Since the center frequency of the CLV mode filter 270 is 22.05KHz, the CLV mode filter 270 is used to filter a main beam push pull signal 250 and extract a narrow bandwidth wobble signal 255 when the speed of the optical storage device is 1x using CLV mode. Since the operational frequency bandwidth of the CAV mode filter 370 is 22.05~55KHz, the CAV mode filter 370 is used to filter the main beam push pull signal 250 and extract a wide bandwidth wobble signal 355 when the optical storage device is using CAV mode. In other words, if the optical storage device is operated in CLV mode, a switch 390 is then connected to the CLV mode filter 270 to output the narrow bandwidth wobble signal 255; if the optical storage device is operated in CAV mode, a switch 390 is then connected to the CAV mode filter 370 to output the wide bandwidth wobble signal 355. Thus, the optical storage device can change the operational frequency range of the multimode filter 300 according to the recording mode.

Referring now to FIG. 4, it shows the block diagram of the CAV mode filter in FIG. 3. As shown in FIG. 4, the CAV mode filter 370 comprises a high pass filter 410 and a low pass filter 430. The high pass filter 410 filters the low frequency content of the main beam push-pull signal 250 and generates an intermediate signal 450, then feeds the intermediate signal 450 into the low pass filter 430 to filter the high frequency content and extracts the wide bandwidth wobble signal 355.

Further, FIG. 5 shows the Bode plot of servo error signals, radio frequency signals, and bandwidth of CAV mode filter. The servo error signals 510 are used for compensating the axial wobble and radial runout when the disk is rotated. Since the axial wobble and radial runout are both physical phenomena and usually results in low frequency error signals. The frequency of the servo error signals 510 are low, for example lower than 3KHz, and the frequency does not change with the speed of the optical storage device. On the other hand, with the frequency response 530 of the CAV mode filter 370, the low corner frequency f_L

can be attained and represented as M×22.05KHz and the high corner frequency can be attained and represented as f_H is M×55KHz, wherein the M is the CAV speed of the optical storage device. Thereby, the CAV mode filter 370 can extract the wide bandwidth wobble signal 355 by adjusting the bandwidth of the CAV mode filter 370 according to the CLV speed of the optical storage device. The data recorded on the disk is RF (Radio Frequency) signal recorded on the tracks 130. There are different length pits and lands formed on the tracks according to the data. The reflection rate of pits is different from lands, it is noted that the data is recorded with the variations of the reflection lights. After transforming the reflection lights, the RF signals 570 are attained. Since the frequency of the RF signals 570 are related to the rotational speed of the disk, the frequency of the RF signals 570 changes with the speed of the optical storage device. That is, the frequency of the RF signals 570 ranges from N×196KHz to N×720KHz, wherein the N is the CLV speed of the optical storage device.

As shown in FIG. 5, the operational frequency domain 530 ranges from M×22.05KHz to M×55KHz. Relatively, the frequency of the servo error signals 510 is low (lower than 3KHz). Thus, the influence of the servo error signals 510 on the wobble signals 355 extracted from the CAV mode filter 370 is limited. Take the second order CAV mode filter 370 for example, the capability of noise depression over the servo error signals is -40dB×log (22.05/3)=-34dB. When the speed of the optical storage device increases, the frequency response 530 of the CAV mode filter 370 is enhanced, however the frequency of the servo error signals 510 does not change. In this way, capability of noise depression over the servo error signals is optimized. Thus, the influence of the servo error signals on wobble signals almost can be neglected when the speed of the optical storage device is high. Further, with the lowest frequency of the RF signals f_{RFL}, N×196KHz and a high corner frequency of the CAV mode filter 370 f_H is M×55KHz, the capability of noise depression of the CAV mode filter 370 over the RF signals can be attained as -40dB×log (196/55)=-22dB. The resulted the capability of noise depression indicates that the RF signals do not interfere with the wobble signal. Moreover, when the speed of the optical storage device increases, the frequencies of the CAV mode filter and the RF signals are enhanced

synchronously. The capability of noise depression of the CAV mode filter 370 is not affected by the difference speed used by the optical storage device.

It is disclosed above that the multimode filter of the present invention can be used for non-wobble signal depression, such as servo error signals or RF signals. In addition, the center frequency can be adjusted dynamically without outside frequency. Therefore, the invention is easy to implement, renders high performance and furthermore it meets the design requirement of the new optical storage device.

While the invention has been described with reference to various illustrative embodiments, the description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to those skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as may fall within the scope of the invention defined by the following claims and their equivalents.